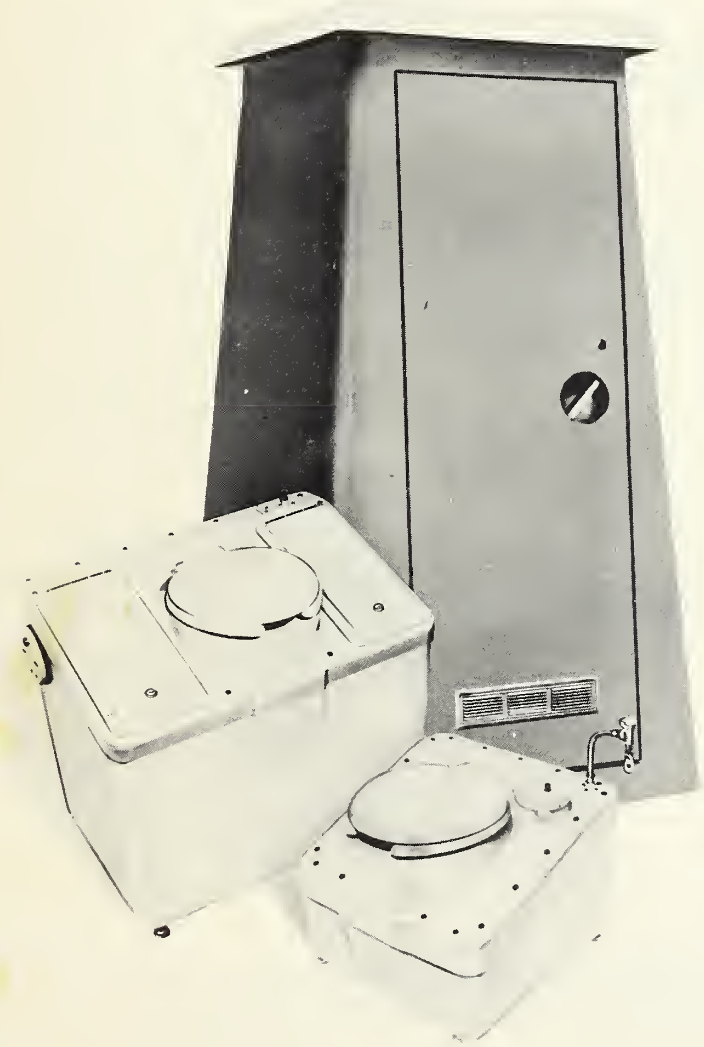
EQUIPMENT DEVELOPMENT & TEST REPORT 2300-5

JET-O-MATIC RECIRCULATING CHEMICAL TOILETS



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U. S. DEPT. OF AGRICULTURE, FOREST SERVICE
SAN DIMAS EQUIPMENT DEVELOPMENT CENTER

EQUIPMENT DEVELOPMENT & TEST REPORT NO. 2300-5

JET-O-MATIC RECIRCULATING CHEMICAL TOILETS

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ABSTRACT

The Jet-O-Matic series of recirculating chemical toilets manufactured by Monogram Industries has been subjected to rigorous laboratory and field tests to evaluate their use at Forest recreation sites. The ability to survive misuse, suppress odor, and handle effluent in ambient temperatures from -20° F to +120° F was evaluated along with economic feasibility.

Both the 1000-flush units (1000M and 1000FE) and the 160-flush unit (160M) performed satisfactorily with the special chemical MC1000. Certain precautions are necessary in extreme conditions, and regularly scheduled inspections and maintenance are recommended.

INTRODUCTION

Sanitary toilet facilities that are esthetically acceptable and convenient are expected by the public in recreation areas accessible by vehicle. Forest Service policy is to provide such facilities. Neither the pit nor the vault toilet is satisfactory, because each is a public health problem and has an inherent odor problem.

Flush toilets, which are preferred by the majority, require a water system and usually, a central treatment plant, thus would be uneconomical to install in a remote area. Also, the freezing winter temperatures of most forest areas preclude the use of flush toilets by late season hunters and winter sports enthusiasts.

Recirculating chemical toilets have been suggested as an acceptable alternative, so a project was initiated for their study. This type of toilet, used in modern passenger aircraft, provides positive odor control with a minimum water requirement. The objective of this project was to locate or develop a satisfactory unit that was adaptable to existing structures and to sites where no structures now exist.

Three models of Jet-O-Matic toilets are considered in this evaluation--the 1000FE, the 1000M, and the 160M. All achieve odor control through use of a special chemical, MC1000. The toilets and chemical are manufactured by Monogram Industries, Los Angeles, California.

The appendix contains dimensional outlines of the 1000M, 1000FE, and 160M. A detailed installation and operations manual is available from Monogram.

Laboratory tests were designed to answer the following questions:

--Will the toilet function satisfactorily in temperatures ranging from -15° to 120° F? How will these temperatures affect battery life?

--What type and quantity of antifreeze is needed, and what is the lowest practical operating temperature?

--How serious are clogging problems caused by addition of foreign matter?

--How susceptible is the unit to vandalism, and how well would it stand forest visitor use?

--Are there any advantages to using 110-volt 60 Hz AC power if available?

DESCRIPTION OF EQUIPMENT

The 1000M is rated as a 1000-flush unit by the manufacturer. It is suitable for use in existing toilet buildings, with minor building modifications (see section of this report entitled "Field Installation"). It is available with the effluent tank drain valve located on the bottom of the tank so that it may be positioned directly over installed vaults for convenient effluent dumping. The price is approximately $700.

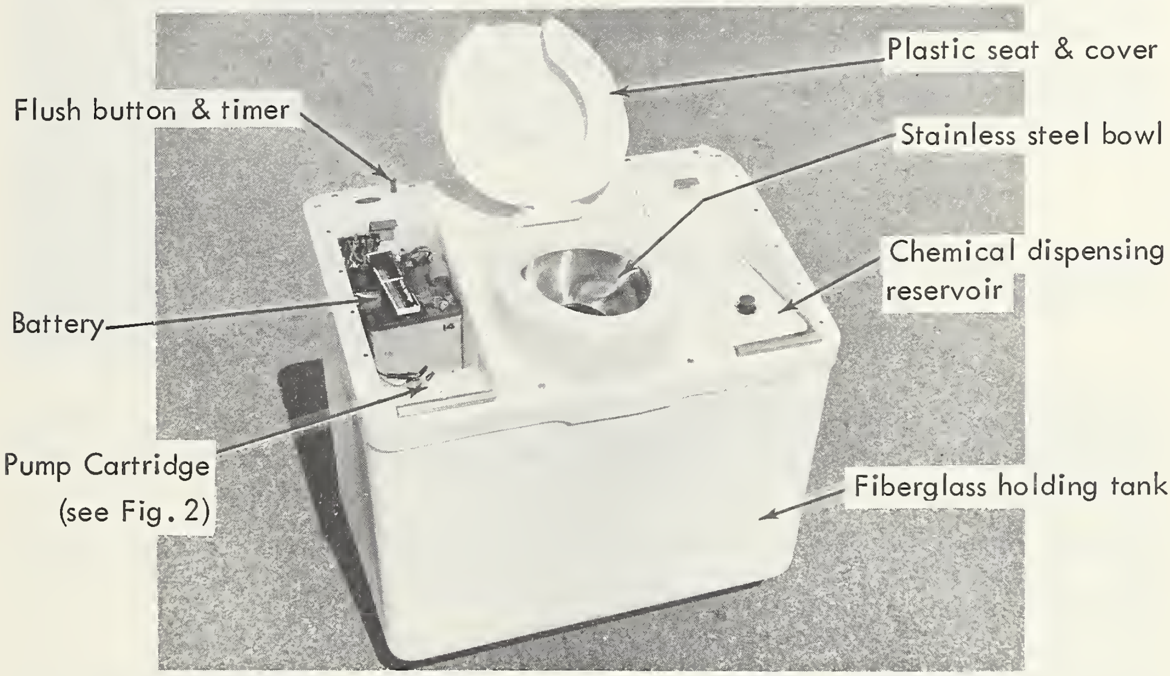


Figure 1. Jet-O-Matic 1000M toilet.

The 1000FE is functionally identical to the 1000M except that it is complete with enclosed shelter. It is suitable for use either where no facilities now exist, or where temporary facilities are desired. It is lightweight and easily portable by truck, and is available in green. 1/

The price of this toilet is approximately $900. (This unit is shown on the cover of this report.)

The 160M is operationally similar to the larger units, but has no chemical dispensing tank or internal battery compartment. It can be retrofitted in existing toilet buildings with little modification of the building except for the installation of a base plate, 3-inch flanges, and a battery compartment. The 160M has a rated capacity of 160 flushes and costs approximately $400. The initial charge of the 160M is eight gallons of mixture; the total capacity is 16 gallons.

1/ Fed. Std. No. 595 - Color 14223 (slightly darker than the green on FS fleet vehicles).

The 1000 series toilets are charged initially with 12 gallons of a water-Jet-O-Matic MC1000 fluid mixture. Fifty gallons of effluent can be added during use, the equivalent of 1000 uses.

Discharge of the toilets is either by gravity through the dump valve in the bottom of the holding tank, or by use of a vacuum discharge pump. The 1000 series toilets are equipped with a service port in the side of the holding tank.

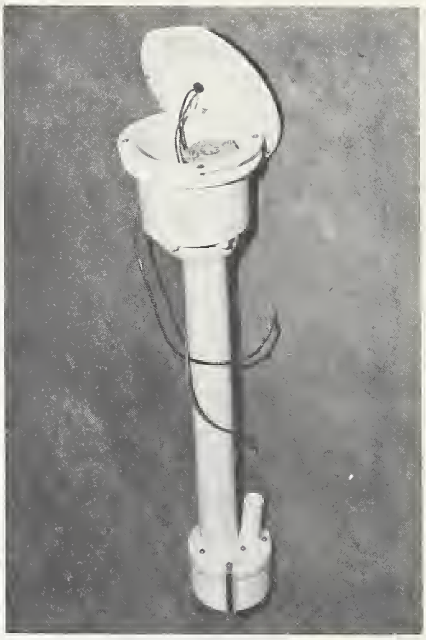


Figure 2. Jet-O-Matic 1000 series pump cartridge and motor.

The MC1000 fluid used in all of these toilets does not effectively treat the effluent, so care must be used in its disposal. Batch loading of small treatment facilities should be avoided.

The main constituent of the MC1000 fluid is formaldehyde. This is the active germicide. It degrades rapidly in the presence of organic material and will not affect organic treatment processes.

A small amount of zinc sulfate is included to sanitize the bowl, and some biodegradable surfactants are used for keeping oily substances in solution. Perfumes are used for odor masking, and a blue food coloring dye is used to "tag" the effluent. The blue dye helps to visibly identify and make obvious any disposal of effluent in unauthorized places.

TEST PROCEDURES AND RESULTS

Laboratory Test Methods

The operation of the toilet was tested by running it through approximately 20,000 flush cycles in an environmental control chamber. Cycling was accomplished automatically by an electrically controlled cylinder that depressed the flush button once every 3 minutes. The slow cycle rate was to prevent overheating the pump motor. Test temperatures were varied from -15° F to 120° F. To simulate actual operating conditions, solid material (paper, sanitary napkins, and other flotsam) and 50 gallons of water-Jet-O-Matic fluid mixture were added to the toilet.

A strip chart recorder recorded the voltage of the electrical source (battery or Monovolt Converter) in order to determine exactly when flushing stopped because of insufficient source voltage.

Records were kept of the battery hydrometer readings and number of flushes completed during each day. A visual check was made of all operating components. The cleaning pattern in the toilet bowl was observed and recorded. The amount of fluid released by the dispensing tank during the operating period was also measured. Observations were made of the flush characteristics as a function of voltage and temperature. Battery life was assessed both experimentally and by calculation.

The unit's susceptibility to vandalism and its physical strength were empirically evaluated. Complications introduced by the addition of antifreeze fluids were investigated, both mathematically and by actual experimentation.

Results

The results are presented in the form of a condensed chronological log (see Table 1). Those interested in obtaining more details of the laboratory tests are referred to Reference 1.

The cleaning-efficiency heading of the Table shows a relative measure of the flushing efficiency of the toilet. It is an indirect measure of the amount of Jet-O-Matic fluid recirculated. Figure 3 shows a 100-percent cleaning pattern. Figure 4 shows a 65-percent cleaning pattern. A desirable minimum level for cleaning is 85 percent.

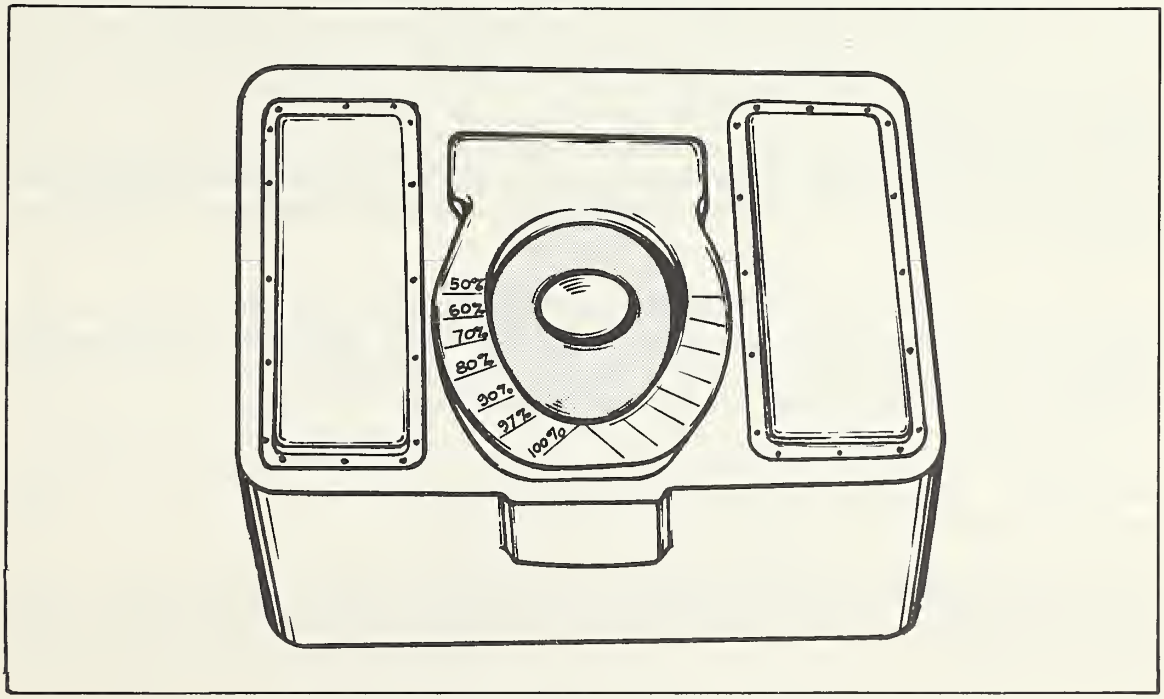


Figure 3. 100-percent cleaning pattern.

An absolute minimum acceptable level is 70 percent. The manufacturer has equipped all models with an improved flush nozzle since these tests.

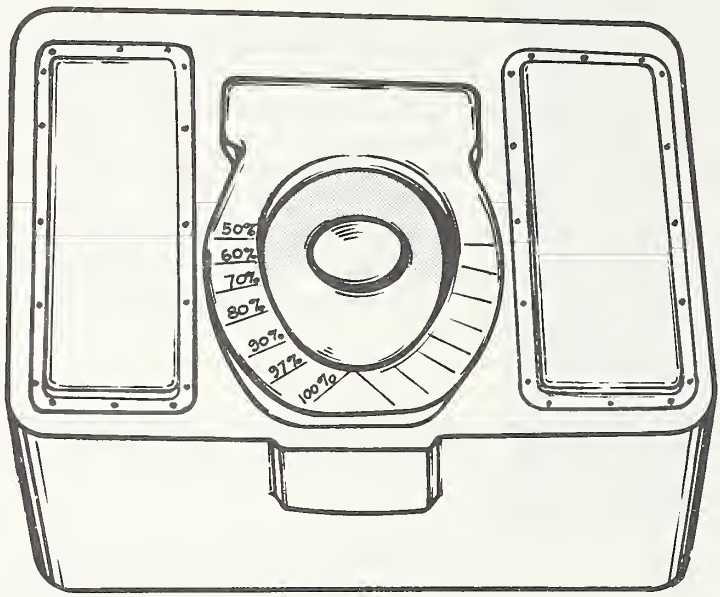


Figure 4. 65-percent cleaning pattern.

Component Failures

Several component failures occurred during the test, but most of these problems have since been corrected by Monogram Industries. Two of the component malfunctions should be noted:

--One of the dispensing tanks received was faulty in operation because the switch lever did not make proper contact with the cam on the large gear, and the switch mechanism was not activated (see Figure 5). The dispensing tank, therefore, did not dispense MC1000 fluid. This is considered a serious fault.

--The second malfunction occurred in the switch timer mechanism and resulted in no flushing. Monogram has since introduced a new switch timer which has not been tested for reliability but appears to be an improvement.

During the entire test period no clogging of the flushing system was observed. With the exception of the component failures mentioned, the toilet performed throughout laboratory tests.

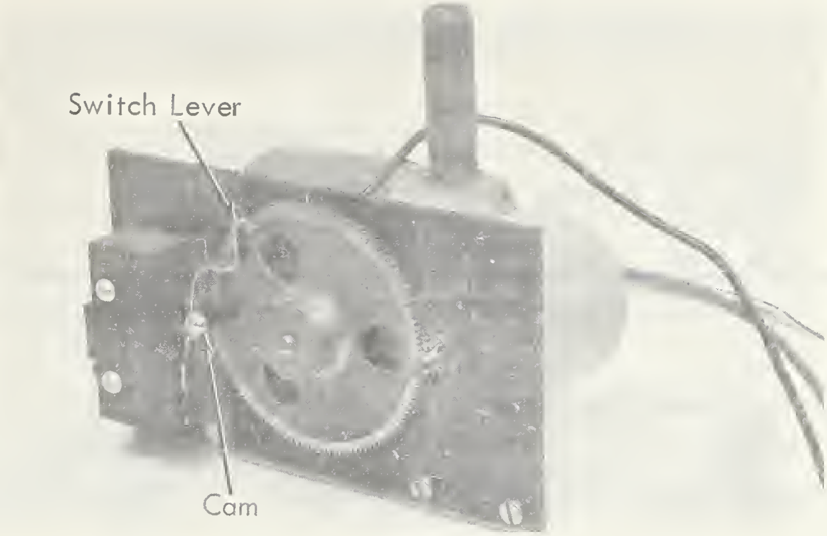


Figure 5. Dispensing tank solenoid operating mechanism.

Antifreeze Tests

Ethylene glycol (Prestone) and calcium chloride ($CaCl_2$) antifreeze were evaluated. On all counts calcium chloride was found to be best suited for protecting the toilets. To protect 50 gallons of water from freezing at 0° F with calcium chloride costs about $7.80, while the equivalent amount of ethylene glycol costs $33.00. Calcium chloride does not increase the viscosity of the holding tank fluid as much as ethylene glycol, and increased viscosity lowers flushing efficiency. $CaCl_2$ has negligible corrosive effects on any parts of the Jet-O-Matic toilets that come in contact with the holding tank fluid, and was found not to adversely affect the MC1000 fluid. (NOTE: Sodium chloride (NaCl) was found to seriously corrode some components of the toilets.)

One caution should be observed when using calcium chloride antifreeze. The lowest freezing point available is approximately -50° F. This point occurs at 29 percent, by weight, calcium chloride. Increasing the amount of calcium chloride in the solution above this proportion rapidly raises the freezing temperature, and may result in crystalline calcium chloride in the solution at low temperatures. Since crystalline calcium chloride is highly abrasive, a mixture of more than 29 percent should not be used.

Under most circumstances, the maximum calcium chloride concentration required in the holding tank was found to be 20 percent, as determined by specific gravity reading of the holding tank fluid. The reasons for this requirement are discussed in the section entitled "Winter Field Test."

Table 1. Data log for laboratory tests.

Dates	Prevailing Temp. °F Holding Tank Fluid	Number of Flushes	Cleaning Efficiency	Approximate No. Flushes Per 45 Amp-Hour Battery Charge	Failures
11-29 thru 12-9	+70° F	4,649	95% or better	2,000	One battery went dead prematurely. Faulty battery.
12-9 thru* 12-16	-10° F to -20° F	1,920	50%-70%	800	Battery acid froze at lowest temperature. Operation erratic and undependable. Cleaning pattern unacceptable.
12-17 thru* 1-7	+10° F to +20° F	4,441	65%-75%	700	First pump cartridge failure. Motor failed.
1-8 thru 1-17	+120° F	4,139	95% or better	2,000	Oppressive chemical odor, 1/ due to expulsion of formaldehyde from Jet-O-Matic fluid.
1-17 thru 1-30	+10° F	5,292	75%	Monovolt converter only	Second pump cartridge failure. Switch failed. $CaCl_2$ antifreeze used.

* Prestone antifreeze used for tests 12-9 thru 1-7

1/ There is little likelihood that this malfunction will reoccur in actual ambient conditions - see page 19, item 10.

Vandalism and Physical Properties Test Results

The test unit was put through a rigorous program of abuse to evaluate its resistance to vandalism and accidental mechanical loads.

One obvious mode of destruction was that of kicking in the front of the tank. The amount of energy contained in a very hard kick was determined and a pendulum was constructed to simulate such a kick. This device administered numerous kicks at temperatures ranging from 5° F to 120° F. No cracking or breakage was observed on the outside of the holding tank. The only obvious damages to the unit were a slight marking of the exterior finish, and a slight cracking of the gel-coat on the inside of the tank.

A 200-pound man jumped up and down on the holding tank top and toilet lid. The toilet survived each of these tests, except that at 5° F the lid failed. There was no damage to the top.

The seat was pulled back with a force of 25 pounds. No damage was noted.

Several acts of vandalism were performed, with results as follows:

1. An attempt was made to carve the holding tank top with a knife. Although carving was possible, it was not as easy as carving wood and should not invite such action.

2. Many external parts can easily be removed with the proper tools, but only with difficulty when using a jackknife.

3. The bowl's rubber boot was found to be susceptible to damage with sticks, knives, etc.

4. The cover panels from the dispensing tank and the battery on the test unit were removable with bare hands. Subsequent units have an improved top-securing system, and bare-hand removal has proved impossible.

5. A smoldering cigarette was left on top of the toilet unit. No real damage occurred. A slight discoloration and a blister on the top's finish was the net result.

Summer Field Test

Thirty-four Jet-O-Matic toilets were placed at recreation sites (shown on the map in Figure 6) during the spring of 1969. Their performances were recorded through the 1969 summer season by Forest maintenance personnel.

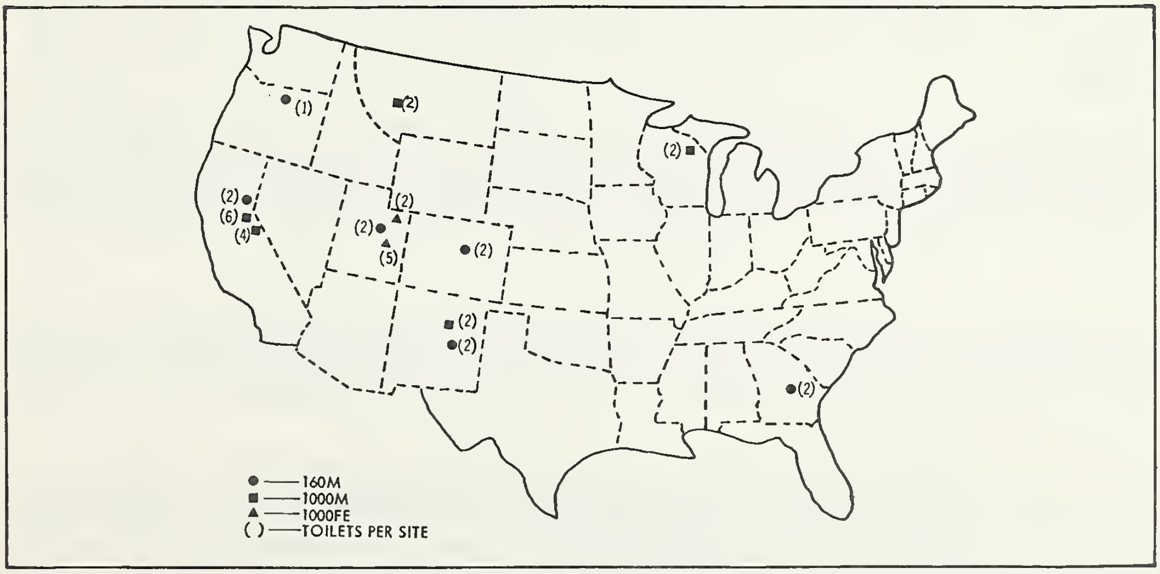


Figure 6. Location of test sites.

Table 2. Summer test results - Averages per toilet.

	160M 11 Toilets	1000M 16 Toilets	1000FE 7 Toilets
Number of days in service	101	101	64
Number of flushes per day	39	20	53
Number of times dumped	23	4	4
Average days of use per dump	6	26	30
Average rinse water per dump	4 gal	20 gal	9 gal
Average number of flushes per battery charge	2,062	1,350	508
Amount of MC1000 fluid used per 120-day period	242 oz	132 oz	137 oz
Average daily service cost, excluding vault pumping	$0.21	$0.15	$0.65*
Average service cost per 120-day period	$26	$18	$78*

*Includes pumping from holding tank.

Results

Table 2 summarizes the data and pertinent results. Each of the figures shown in the Table is an average "per toilet" value for each of the toilet types. The total number of flushes for the entire summer field test phase was approximately 93,000, with the 160M's receiving 40,000 flushes, the 1000M's 32,000, and the 1000FE's 21,000 flushes.

The average days-of-use-per-dump figure is weighted to consider equally the data from each toilet. Because of this, this number of times dumped for each toilet, divided into the corresponding days of service, does not necessarily give the average days of use per dump.

The average rinse water per dump shows the amount of water that the maintenance crew considered necessary to sufficiently clean the toilet before each recharge, and should be considered in vault or holding tank sizing. The average daily service cost does not include the cost of vault pumping, nor of transportation to and from the toilet site, but only of the cleaning and maintenance of the toilets. The cost does

not include toilet maintenance supplies. When reviewing these cost figures they should be compared with cost figures for existing pit, vault, and conventional flush toilets.

The amount of MC1000 fluid used, and the average service cost per 120-day period, are the figures that should be used when computing the seasonal cost of maintaining a Jet-O-Matic toilet in a Forest Service recreation site.

From the numerical data several observations can be made:

1. In general, the 160M toilets required dumping about once a week, while the 1000-series toilets, having a larger capacity, required dumping only about once a month. Because of higher number of dumps on the 160M, the average daily service cost is higher than that of the 1000M's. However, both the 1000M and the 1000FE have the added complication of a chemical dispensing reservoir with its attendant service problems. Proper sizing of the units to match the use rate would reduce the differences in dump frequency and service costs.

Other factors affected cost of the 1000FE because the maintenance operators included in their report-of-service cost the cost incurred in pumping from the holding tank. This was a difficult operation for two of the seven test units, since they were located on an island with boat access only. There is no reason, other than the holding tank dumping procedure, why maintenance costs should be higher for the 1000FE than for the 1000M. Operationally, they are identical and the holding tanks have the same capacity.

Since the 1000FE is a self-contained unit, the holding tank must be pumped out when full. No 1000FE's have been located directly over vaults, although this arrangement is possible. All of the 1000M's tested were mounted directly over vaults. When their holding tanks were full they were dumped directly into the vault, thus no pumping was involved. Water under pressure for rinsing was available at most of the 1000M sites, while only "bucket" water was on hand at the 1000FE's. The extra labor involved in hand rinsing explains the discrepancies in the "Average rinse water per dump" column, and also contributes to the higher service cost.

2. Physical size of the battery compartment of the 1000M and the 1000FE limits the size of the battery which can be used. The 160M battery is external from the toilet unit so batteries of larger size with higher ampere hour capacity were used. This resulted in a higher number of flushes per battery for the 160M's.

The 1000FE batteries may have been changed prematurely because of the remote location of the toilets. Since access to the units was difficult, it seems logical that maintenance personnel might have wanted to preclude any chance of toilet failure. The 1000FE battery life should be equal to that of the 1000M.

3. The 160M's received twice the average daily use of the 1000M's, which indicates that incorrect capacity toilets were selected for some sites.

Storage Precautions

Storage after field laboratory tests revealed that a certain amount of paper pulp may remain inside the pump cartridge. If allowed to dry out this pulp becomes quite hard and thus prevents the pump from operating. When the pump motor is energized subsequent to the hardening of this paper, the motor cannot turn; therefore it overheats, and either burns out the motor or the fuse.

Three alternatives are available for off-season storage:

--The first, and most desirable, is to remove the pump cartridge at the end of the use season, wash it out completely, and reinstall in a well-cleaned tank.

--The second is to store the unit with enough water to cover the pump and strainer completely. In this case, the unit must be protected from freezing.

--The third alternative is to wait and clean the pump before placing it back into service. This is more difficult because the paper hardens and becomes quite difficult to remove.

Similar storage precautions should be employed when a holding tank dump valve is installed because hardened paper can foul the sealing edge of the valve.

Public Use Patterns and Comments

One toilet was instrumented with a strip chart recorder which recorded the number of times flushed during each hour of the day. There was almost no use between the hours of midnight and 6 a.m., and no marked peaks of use during the day.

Comments from the public were obtained and found to be very favorable. One District conducted its own survey of public opinion and found the comments uniformly well-disposed.

Comments from the Field

Comments were received from Regional, Forest, and District recreation staff and administration, and from personnel in charge of maintaining the toilets. A summary of conclusions and recommendations from all eight Regions showed them to be uniform and were as follows:

1. The chemical dispensing reservoir on the 1000 flush units is undependable. Maintenance personnel state that human judgement is necessary to decide when more MC1000 fluid is necessary to control odor. No adverse comments were received from either the field or the public about the odor control of the 160M toilet.

2. Except during periods of light use, daily cleanup and serviceability check of each type of toilet is a necessity. Present policy is to maintain vault toilets daily, so this should present no added cost burden. If toilets were maintained daily, a small amount of MC1000 chemical could be added by hand each day and the chemical dispenser would not be needed.

3. Maintenance men observed that the solid portion of the effluent, not only human waste but beer cans, fish entrails, etc., had to be forced through the drain valve manually. Although a larger bottom drain valve or sloping tank bottoms would be a help, some mechanical pushing would still be necessary to remove the heavier portions of the holding tank contents.

4. The flush button repeatedly sticks on all three toilet designs. (NOTE: The field test toilets were all equipped with the old style flush button timer.)

5. Freezing occurred during summer tests but caused no malfunction of the toilets.

6. Maintenance men consistently requested a complete service and operating manual, and Monogram Industries has not made one available.

7. Public reaction was uniformly enthusiastic.

8. Even the most reserved Forest Service employees involved with the toilets agreed that recirculating toilets are an improvement over vault toilets. The most enthusiastic said they compared favorably with conventional flush toilets.

9. Field comments indicate that disposal of effluent will not be a problem. The intense blue dye incorporated in the MC1000 fluid was disliked by some who were actually involved in cleaning the toilets. However, this blue dye is necessary to insure proper disposal of the effluent, and is required by law in some States.

10. Complaints that severe odor and eye irritation were caused by high ambient temperatures were investigated and found to be greatly exaggerated. Only one or two complaints of this nature were received and these were not deemed serious even by those who reported them. Vents on the later model tanks will reduce or eliminate this problem.

11. The location of the flush button on the 1000M is such that it is not readily seen when the toilet seat and lid are up. This problem is not so serious as to warrant relocation of the flush button.

12. The 1000M toilets are too tall to reach comfortably. A step, built-up floor, or sump in a modified building must be used. The practice of providing concrete blocks for steps is unsatisfactory.

13. Vandalism was not generally experienced during the summer test. The only exception was the near destruction of one 1000FE. This toilet was locked and out of service at the time severe vandalism occurred. This indicates a need for scheduled inspection and maintenance even for units not in service.

14. Instructions to the users on how and when to flush the units should be provided by the manufacturer. Locally lettered signs are a poor compromise.

15. A few test toilets were reported to have blown fuses. These were earlier units equipped with improper size fuses. When the proper size and type fuses now recommended by Monogram were installed, no further difficulty was encountered.

Winter Field Test

One 1000M unit was placed at the Grassy Point Boat Landing at Georgetown Lake on the Phillipsburg District of the Deerlodge National Forest, Northern Region. This area has severely cold winters with a considerable amount of ice fishing on Georgetown Lake. This provided a combination of hostile ambient conditions and fairly heavy use under winter conditions.

The test toilet was instrumented to provide a continuous record of battery voltage, number of flushes, and holding tank fluid temperature. In addition, the air temperature in the interior of the toilet building was continuously recorded, and the daily outside ambient maximum and minimum temperatures were recorded. Each day the specific gravity of the holding tank contents was measured, as was the level of the effluent. This allowed the calculation of the percent of calcium chloride in the holding tank.

The winter test period extended from November 21, 1969, until March 2, 1970.

Results

During the test period, 485 flushes were recorded. It is strongly suspected that under the winter conditions the toilet was getting more use as a urinal than the flush count indicated because with the toilet seat up the flush button is not easily seen. Although at low temperature bowl cleaning is not as good as at warmer temperatures, cleaning was satisfactory at holding tank temperatures down to 2° F, the lowest encountered during the test.

No difficulties unique to the winter operation were seen. However, some trouble with the flush button, as with the laboratory and summer tests, was recorded. The button sometimes sticks for a period up to 10 minutes and releases. This could cause motor failure. Two switches on toilets not part of the test program but in use at winter recreation areas in the Pacific Northwest Region also showed this malfunction.

One battery served for the final 95 percent of the flushes during the winter test. At the end of the test period, no discernible difference in specific gravity or battery voltage was noted.

Antifreeze Considerations

Calcium chloride antifreeze was used exclusively for this test. Twenty percent $CaCl_2$ was mixed into the initial water charge. To insure complete solution of the $CaCl_2$, the water was heated slightly to speed dissolution and allowed to cool before being poured into the holding tank. During the test, the holding tank froze five times as indicated in Table 3. Note that early in the test, the tank froze at temperatures lower than those predicted by the specific gravity of the holding tank fluid. Later in the test, as more foreign matter was added, the tank froze at temperatures slightly higher than that predicted by the specific gravity of the effluent. The formation of as much as 4 inches of ice on the surface of the holding tank is not detrimental to the operation of the flushing system, unless the pump and strainer freeze. As the surface freezes, the portion of the holding tank contents' remaining fluid becomes

richer in calcium chloride; thus additional antifreeze protection is provided.

It was found that the specific gravity of the holding tank could be used as a rough measurement of its lowest safe operating temperature. There appeared to be no need for protecting the holding tank to the lowest expected atmospheric temperature. Although atmospheric temperatures dipped as low as -28° F during the tests, the lowest holding tank temperature recorded was 2° F. Therefore, it seems reasonable that if the holding tank's specific gravity is maintained at 1.19 (20% calcium chloride, or enough to protect the holding tank to 0° F), very little chance of serious freezing will be encountered.

The temperature of the air in the toilet building was found to be approximately midway between the outside air temperature and the holding tank temperature.

Field Comments

Although no public comments were directly available about the winter test installation, the maintenance personnel (who had one summer season experience with Jet-O-Matic toilets at the same location) feel that the qualities which made the toilets desirable for summer recreation installations also make them desirable for winter recreation site use. No particular difficulties are encountered in winter use, and they were entirely satisfied with the cold weather operation of the Jet-O-Matic.

Although the winterized MC1000 fluid became so viscous at extremely cold temperatures (0° F and lower) that it did not properly dispense, it did not freeze at any time. Odor control is no problem at temperatures below zero, so this problem was not considered serious.

Electrical Considerations

Regular service from an electric powerline is preferred for the Jet-O-Matic toilet. Two facts elicit this comment. The first is that, as temperature decreases, viscosity of the fluid to be pumped increases. With increased viscosity, more electrical power is necessary to operate the pump and provide a given degree of cleaning. As temperature goes down and as time goes on, less electrical power is available from a battery. The second is that the ability of the battery to retain its charge over a period of time, regardless of use, decreases with the age of the battery and also with the number of discharge-recharge cycles that the battery has experienced. The batteries utilized in the Jet-O-Matic 1000M and 1000FE are size limited. The size recommended, and the largest one that will fit in these units, is a size 22, normally rated at about 45 amp-hours. The size is common in compact cars. A larger, longer life battery would be more desirable. The 160M battery is external to the unit and is, therefore, not size limited. Summer field tests--in which size 22 batteries were used in the 1000M's, and larger batteries were used in 160M's--substantiate this.

Figure 7 is a curve of percent of cleaning efficiency versus power consumed under load. It is seen that the higher the temperature the greater the cleaning efficiency obtained at any given power consumption. In theory, the 45 amp-hour size batteries recommended by the manufacturer should provide over 1000 flushes with considerable reserve. Table 1 shows that at sub-zero temperatures this is not the case, but under

Table 3. Freezing incidents.

Date	Holding Tank Temp. °F	Lowest Outside Ambient Temp. in past 3 days, °F	% Calcium Chloride[a] in Holding Tank	Expected Freezing Point, °F (Based on % $CaCl_2$)
12-29	20	-7	11	21
1-5	8	-28	16	11
1-12	2	8	19	3
1-30	25	-8	17	9
2-20	20	0	16	11

[a] based on specific gravity of holding tank fluid.

field conditions at less severe ambient temperatures, over 1000 flushes were obtained from each battery charge.

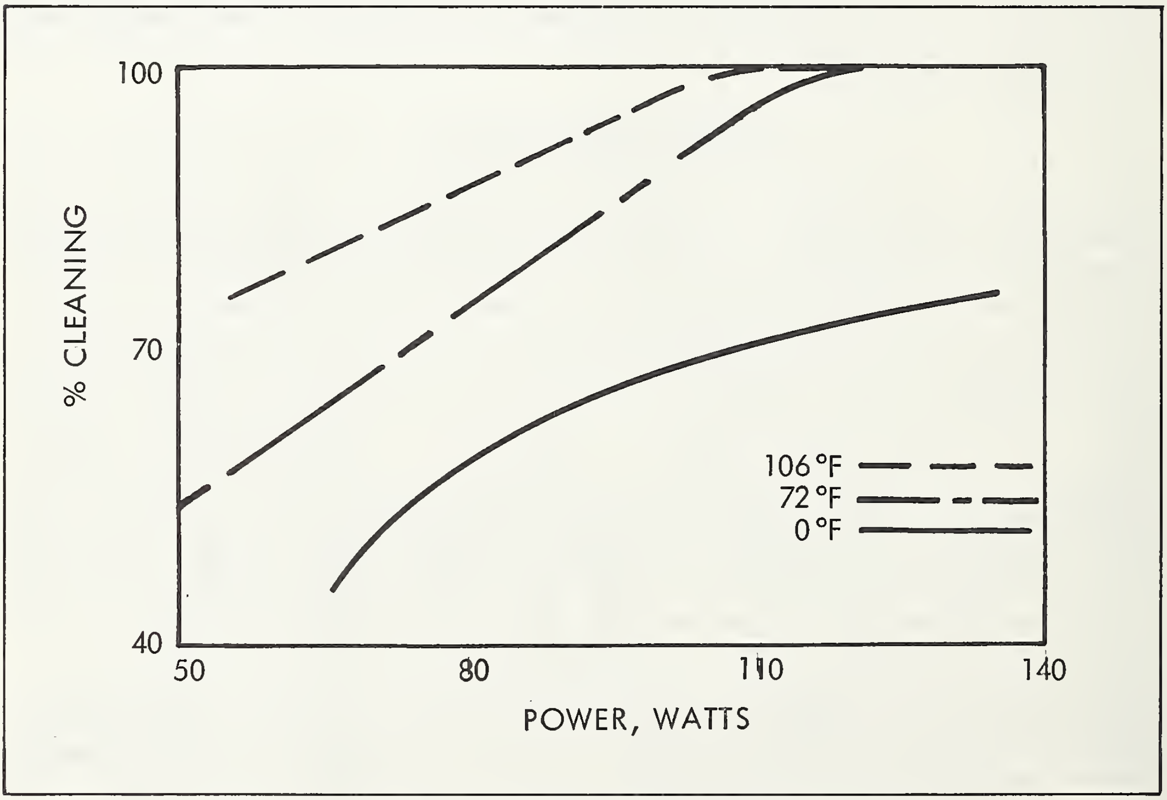


Figure 7. Cleaning efficiency as a function of power.

Monogram Industries can supply a converter which provides 12 volts DC for three toilet models from 120-volt 60 Hz AC line power. The price is approximately $30, and one was used to supply power during the laboratory tests. If 120-volt power is available at the toilet site, its use is suggested, since the converter costs approximately the same as two batteries. The cost of electrical power to operate the converter is negligible.

Battery Life and Servicing Procedures

The manufacturer's recommendations should be carefully observed when charging batteries. Exceeding the recommended safe rate of 1 ampere per positive plate per cell may damage a battery through overheating and plate corrosion.

FIELD INSTALLATION

The simplest Jet-O-Matic field installation is the 1000FE, since it needs merely to be located on site and charged before being placed in service. It can be located directly over a vault for ease of dumping since it is available with a bottom dump valve. If it is placed directly over a vault, the vault should have a side branch opening to allow pumping without moving the toilet.

The 160M is well suited to installation in existing toilet buildings since it is small and low enough so that it does not need a built-up step in front of it. Since this toilet has no built-in battery compartment, the battery must be housed separately from the toilet. It should be located in a locked area to prevent theft. Wires leading from the flush button to the battery should be encased in either rigid or flexible conduits for protection. Figure 8 shows a snap-in metal shield to prevent unauthorized access to the dump valve on a 160M installation. This, or similar protection, is suggested. A side cleanout should be provided a vault when a 160M is mounted over it, as with the 1000FE.

Field installation of the 1000M in existing toilet buildings is less straightforward than that of the other models. The physical size of the 1000M is such that it will not fit through some doors and it is sometimes necessary to lift the building with a crane. If placed in an existing building, a built-up floor or sturdy platform should be provided since the 1000M is so high it is uncomfortable to sit on without a platform in front. If a new building is to be erected for the 1000M's, then an elevated floor or sunken sump area for the toilet can

Figure 8. Snap-in protector.

be provided. It is quite important to provide a side access port for pumping the vault over which the 1000M is located. Although the most expensive and difficult installation, this is probably the most satisfactory permanent installation with chemical recirculating toilets.

A device is available for all three Jet-O-Matic toilets with bottom drain valves that allows the quick attachment of the toilet to the vault below. This is known as the drain valve extension fitting and is shown in Figure 9.

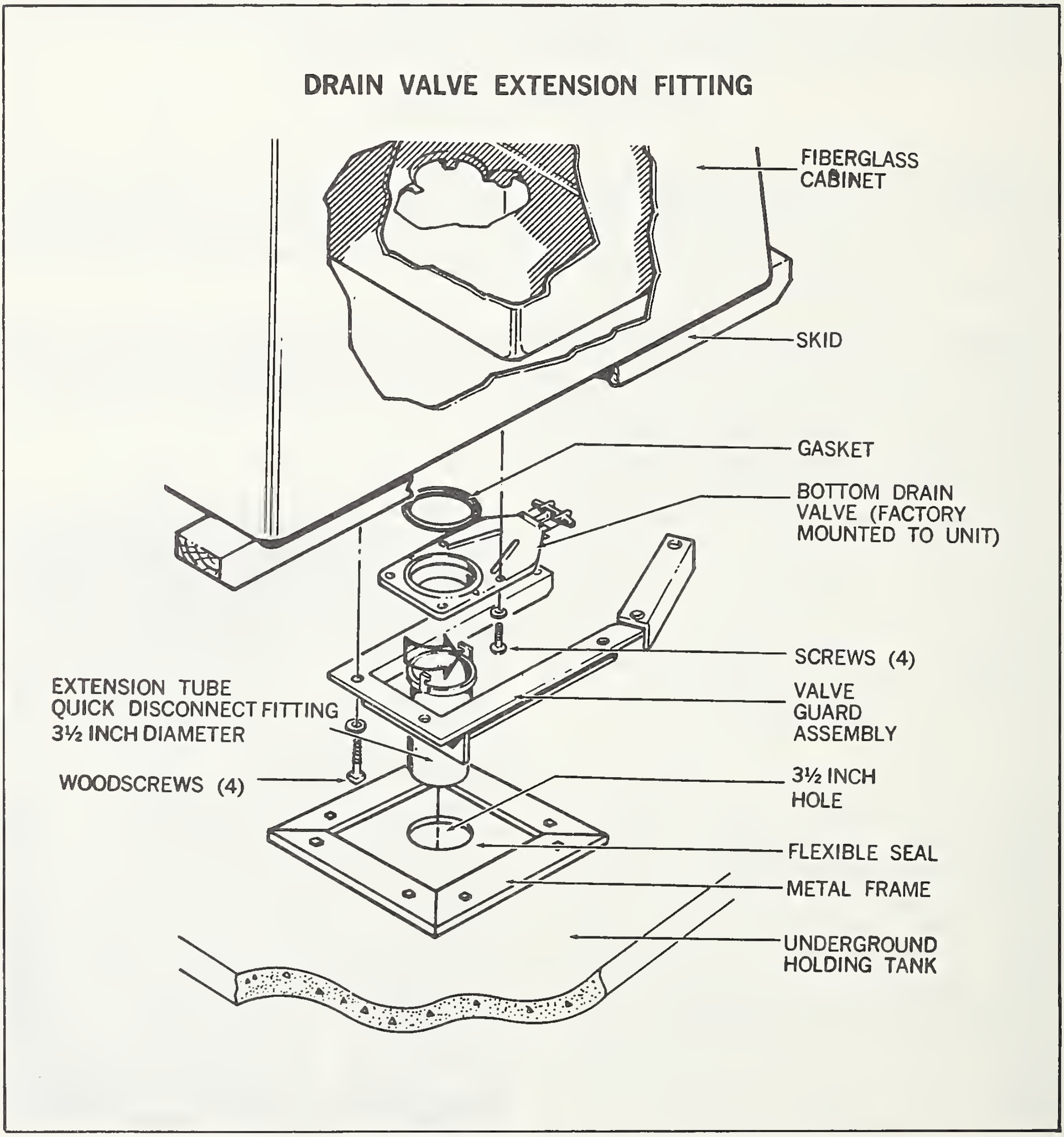


Figure 9. Drain valve extension fitting or 1000FE vault adapter.

CONCLUSIONS

1. The durability and function of all three models of Jet-O-Matic toilets are satisfactory for Forest Service recreation sites during both summer and winter. Most parts of the toilets shown to be weak during testing, including the flush button timer, have been improved by Monogram Industries. The chemical dispensing reservoir is still an undependable feature. Need for this device has been questioned by field personnel, and it is not essential for effective operation of the 1000M and 1000FE.

2. All three Jet-O-Matic toilets achieve satisfactory odor control with much less water than flush toilets.

3. Public acceptance of all three models of toilets during both winter and summer use has been exceptionally good.

4. Field personnel consider the toilets to be a significant improvement in recreation facilities sanitation.

5. Automotive batteries and the Monovolt Converter will provide the electrical power necessary to operate the toilets.

6. Regular inspection and maintenance is necessary for the proper operation of these toilets.

7. Properly maintained and serviced Jet-O-Matics are no more subject to vandalism than conventional types of toilets.

8. Calcium chloride should be used as the antifreeze for winter operations if temperatures below freezing are expected.

9. The choice of the 1000FE, 1000M, or 160M depends largely on projected use, budget considerations, and permanence of installation.

USE RECOMMENDATIONS

The following use recommendations are made:

1. Depending upon the Jet-O-Matic model being considered--

--the 160M should be used to convert existing small toilet buildings, or when the use load is such that it justifies only the 160-flush capacity.

--the 1000M should be used to convert large existing toilet buildings, or in new chemical recirculating toilet facilities when a higher use load is expected.

--this model should be used for temporary toilet facilities and permanent facilities where the 1000FE enclosure is suitable.

2. 120-volt 60 HZ AC power should be used when available.

3. The toilets must be serviced regularly.

4. Seasonal storage should be preceded by a thorough cleaning of the entire toilet, and especially the pump.

5. Calcium chloride should be used as a holding tank antifreeze. Normally, the specific gravity of the holding tank should be maintained at 1.19, or 20 percent calcium chloride by weight.

6. The improved flush button timer should be retrofitted to all toilets presently in the field and having the original timer.

7. The installation of the chemical dispensing reservoir in the 1000M and 1000FE models should be optional with the purchasing unit until its dependability can be improved.

8. Provision should be made to prevent unauthorized or accidental discharges of the holding tanks of all models.

REFERENCES

1. "Recirculating Chemical Toilet," ED&T 1956 Project Record, by Harrison, R. T., U.S.D.A., Forest Service, Equipment Development Center, San Dimas, California, May 21, 1969. (Available on request.)

2. "Chemical Recirculating Toilets Summer Field Tests," ED&T 1956 Project Record, by Harrison, R.T., U.S.D.A., Forest Service, Equipment Development Center, San Dimas, California, January 20, 1970. (Available on request.)

3. Handbook of Chemistry and Physics, 40th Edition, Chemical Rubber Publishing Co.

4. "Battery Service Manual," Association of American Battery Manufacturers.

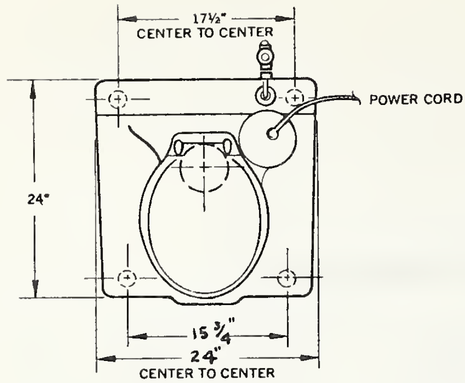
APPENDIX

Calcium Chloride Brine Freezing Points

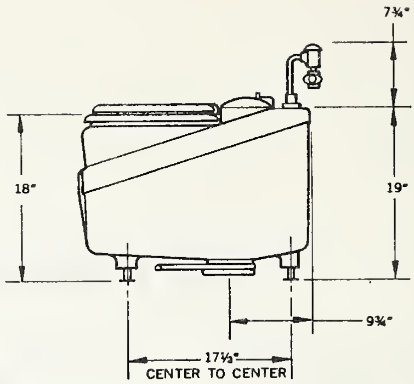
Specific Gravity	% $CaCl_2$, Weight	Freezing Point, ° F
1.000	0	32.0
1.020	2.3	30.2
1.040	4.6	28.0
1.060	7.0	25.9
1.080	9.2	23.2
1.100	12.4	18.7
1.120	13.5	16.5
1.140	15.6	12.2
1.160	17.6	7.0
1.180	19.5	+ 1.2
1.200	21.5	- 5.8
1.220	23.3	-13.2
1.240	25.1	-21.5
1.260	27.0	-31.2
1.280	28.7	-44.3
1.300	30.5	-41.8
1.320	32.2	-17.0
1.340	34.0	+ 4.3
1.360	35.8	21.7
1.380	37.4	37.0
1.400	39.2	50.9

From Reference 3, p. 2309

Outline and Mounting Dimensions

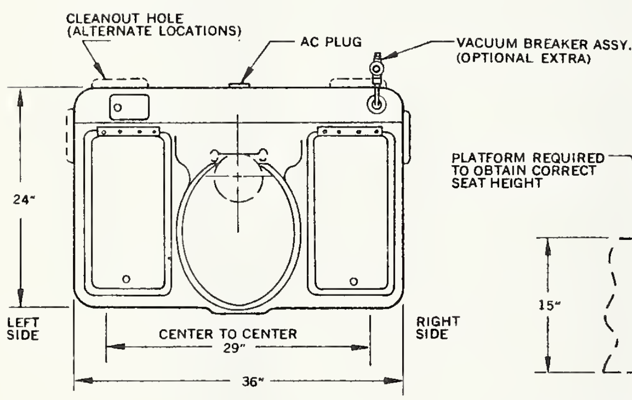


TOP VIEW



SIDE VIEW

160M



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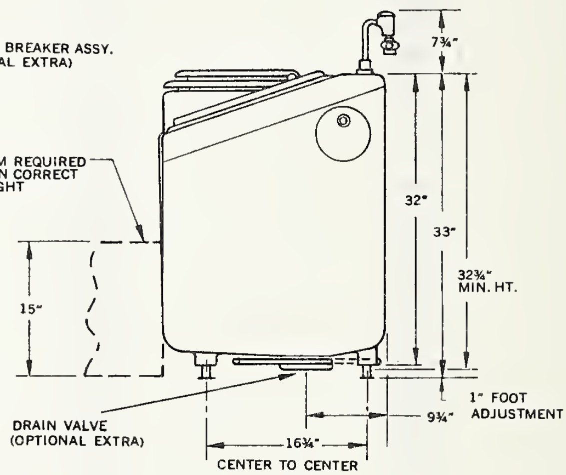
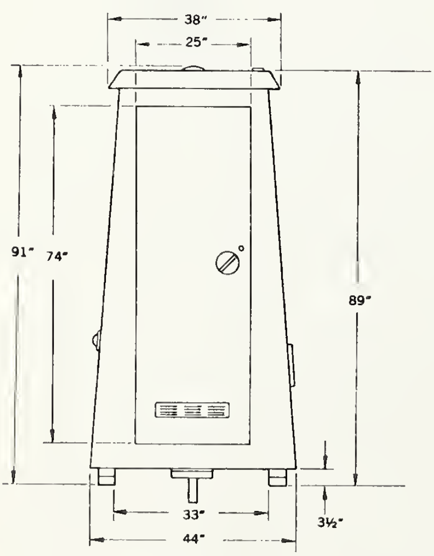
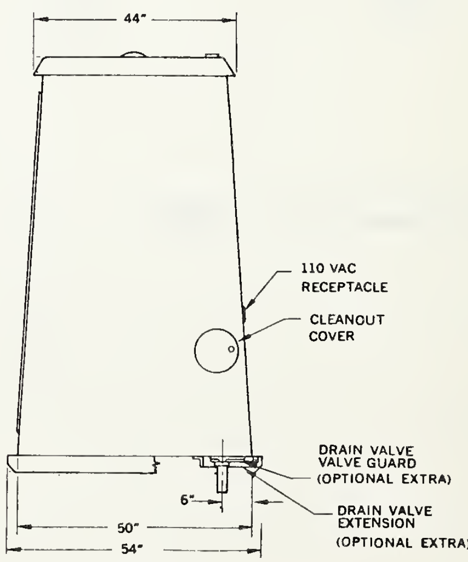


SIDE VIEW

1000M



FRONT VIEW



SIDE VIEW

1000FE